# DEA efficiency of German savings banks: Evidence from a goal-oriented perspective

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## Abstract

We provide one of very few Data Envelopment Analysis efficiency studies of the German savings banks, thereby contributing evidence on the credit of their business model. This model distinguishes itself by the ultimate purposes to ensure public access to financial services and to support regional economies. To capture the respective goal set of the German savings banks, we propose a framework incorporating rationality concepts of decision making to derive appropriate performance criteria. On this basis, the 2006–2011 analysis reveals the active role of the savings banks in stabilizing the German economy during the financial crisis 2008–2009. The results also suggest that the banks are more efficient in fulfilling their public mandate than in generating profit. Furthermore, a stable scale efficiency pattern is observed, particularly showing that larger banks are experiencing notable decreasing returns to scale.



## Keywords

Bank Efficiency, Data Envelopment Analysis, Decision Making Criteria, German Savings Banks, Scale Efficiency

## JEL classification

C21, C67, L25


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## 1. Introduction

The savings bank business model has a long history which dates back to the year 1788 when the first savings bank was founded in Hamburg with the title "Ersparniskasse". Since then, savings banks developed into an important banking sector in Europe (Gardener et al. 1997). The primary purpose of savings banks is not to maximize profit, but to ensure the universal access to financial services for the general public and thereby to support regional economic development. Without private owners, they are oriented toward multiple stakeholder values. The resulting goal set distinguishes them from their commercial counterparts, although savings banks also conduct universal banking operations today and compete under commercial principles.

With this in mind, our study aims to provide evidence on the credit of the savings bank business model from a goal-oriented perspective to capture the values which savings banks pursue. The German savings banks which still maintain the original business model of savings banks to date are taken as the research sample. These banks hold an important role in the national banking system. By the end of 2012, 423 active savings banks occupied around 21% of the total lending market and around 24% of the total deposit market in Germany, with a savings deposit share of 48%. This was achieved with 244,862 employees working in 15,295 branch offices and taking care of the accounts of about 35 million people (DSGV 2012a).

Our data set covers a 6-year period from 2006 to 2011 of 396 German savings banks which account for about 94% of total assets of the whole savings bank sector in Germany (in 2011). Based on the concept of Data Envelopment Analysis (DEA) efficiency, our study addresses three questions: (i) To what extent do the banks meet the values of their stakeholders, especially compared to the profit maximization assumption? (ii) How well did the banks overcome the financial crisis 2008–09? (iii) What conclusions can be drawn from the relation between the size of the banks and their scale efficiency? The empirical analysis takes up the challenge that the profit maximization assumption of conventional performance measurement models is not valid for the banks and provides a customized DEA efficiency analysis. Instead of measuring technical efficiency merely based on the relation of inputs and outputs, the efficiency of the savings banks is measured with reference to the accomplishment of the goals which correspond to stakeholders' values. Thereby, the respective framework contributes to solve the input/output specification problem of DEA which is especially discussed in the context of bank efficiency studies.

The rest of the paper proceeds as follows. Section 2 provides a brief background discussion on the performance measurement of savings banks. Section 3 proposes the performance

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measurement framework to specify performance criteria for the German savings banks. On this basis, the results of a DEA analysis on the banks' efficiency, including their scale efficiency, is presented in Section 3. Section 4 concludes the paper.

## 2. Background

In the current literature, Bergendahl and Lindblom (2008) as well as García-Cestona and Surroca (2008) which apply DEA for measuring the performance of savings banks also draw attention to the issue of customizing the respective measurement model. The study by Bergendahl and Lindblom (2008) on Swedish independent savings banks originated from the observation that savings banks are less profit oriented than commercial banks. The authors argue that the service efficiency concept is more appropriate to evaluate the success of the savings banks than the traditional profit concept as these banks do not have private owners. Their results show that there are more service efficient ones than profit efficient ones among Swedish savings banks. With a view to the multiplicity of goals of Spanish savings banks, García-Cestona and Surroca (2008) specify the need to replace traditional efficiency indicators and investigate how the banks create values for their stakeholders. Their measurement model incorporates the perspectives of the founders, the public, the administrators and the employees as the key stakeholders. On examining the impact of different ownership structures on technology and goal priorities including the importance given to the profit maximization goal, the study reveals that it is not reasonable to evaluate the performance of multi-objective organizations like savings banks by economic results only. The findings indicate that the distinct goal set of savings banks together with the lack of shareholders calls for a move beyond the traditional performance measurement models which assume profit maximization as the primary objective of organizations.

In respect of deriving performance criteria for savings banks, the main bank behavior models developed for commercial banks – the intermediation approach, production approach, user cost approach and value added approach – have been most popularly employed as the anchors. For example, Griffel-Tatjé and Lovell (1996) as well as García-Cestona and Surroca (2008) referred to the production approach, while Tortosa-Ausina et al. (2008) used the intermediation approach. However, we believe that the reference to the conventional behavior models is not sufficient to derive performance criteria for savings banks. Even though these models refer to the production process, they are unable to take the distinct goal set of savings banks into account.

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The finding above is drawn from strictly distinguishing between the process aspect and the goal aspect inherent in these bank behavior models. Concerning the process aspect, savings banks are quite similar to commercial banks. They take the same roles in societies, e.g., as financial intermediary or as service producer. Input and output factors of commercial banks thus can also be valid for the case of savings banks. This finding is nevertheless not transferable to the goal aspect, since the conventional behavior models commonly assume profit maximization. They are only different regarding the instrumental goals to raise the shareholder value (Ahn and Le 2014). For instance, the intermediation approach focuses on maximizing the market value of financial intermediary services, while the production approach focuses on minimizing operating costs. However, the ultimate purpose of savings banks is not to maximize profit. In fact, savings banks are oriented toward multiple stakeholder values, not toward the shareholder value. It thus can be argued that the performance measurement models for savings banks need to be explicit about and customized to their multiple values.

## 3. Performance measurement framework for the German savings banks

The German savings banks form a homogenous group within the Savings Banks Finance Group which is represented by the Deutscher Sparkassen- und Giroverband (DSGV). Under the instruction of the DSGV, these banks share uniform risk management tools with standardized evaluation criteria. They are all established as “institutions under public law” and operate with the public mandate under the regional principle (DSGV 2012b). Also, they target the same business mission and follow the same business model with a common strategic focus and a strong common brand (“Sparkasse”). Today, they still pursue the founding mission which is “to provide the wider public, businesses, and local authorities in their region with banking services” (DSGV 2012a). Given such homogeneity, a DEA-based benchmarking assessment on German savings banks seems to be appropriate.

There are already several studies within this topic. For example, Gubelt et al. (2000) used DEA to measure the efficiency of the German savings bank for the year 1996, emphasizing a systematic approach to structure input/output factors. Poddig and Varmaz (2005) reflect upon DEA efficiency changes over time and compare the savings banks with credit cooperatives. Bresler (2007) as well as Radomski (2008) applied DEA models to investigate the success of mergers in the German savings bank sector. Finally, Tischer (2011) takes regional differences of the banks into account by applying cluster analysis. All these contributions give valuable insights into different aspects of the performance of German savings banks. Independently

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from their respective focus, however, we believe it is essential to adopt a goal-oriented approach for taking the distinct goal set of the German savings bank into account.

Section 3 therefore aims to derive specific objectives for maximizing and for minimizing (in the first place, rather than input and output factors) as performance criteria to capture the goals of German savings banks. To this end, we propose the Decision-oriented Performance Measurement (DPM) framework[1] as a four-step process based on rationality concepts of decision-making. The framework incorporates decision making criteria[2] at four hierarchical levels, namely the value setting level, goal setting level, objective setting level and factor setting level. The framework addresses the correspondence between the performance of an organization on the overall goals and the values expected from its stakeholders. The expected values for the German savings banks are determined from the fundamental values of both primary stakeholders and secondary stakeholders, while the overall goals are specified through their strategies and behavior models. To quantify the respective correspondence, a set of specific objectives is derived, including not only primary objectives and necessary resources but also positive and negative side effects. These objectives, designated to reflect the fundamental values of stakeholders as well as the accomplishment of the overall goals of the banks, are finally modeled as value functions of the banks' input and output factors.[3] With this design, the framework is also expected to tackle the input-output specification issue in other DEA-based bank efficiency studies which remains an ongoing debate so far.

Table 1 below summarizes the set of performance criteria of German savings banks as the outcome of applying the DPM framework for both the intermediation approach and the production approach. These are the two bank behavior models which have been most popularly employed in DEA-based bank efficiency studies. More importantly, they already cover and contrast the two main aspects of the banking process, i.e. the fund intermediating aspect and service producing aspect. Our respective considerations are now step by step depicted.

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1. More details about the framework and its application can be found in our working paper *(not yet specified for the reason of anonymity)*.
2. The decision making criteria represent different goal systems which direct how decisions should be made. In this study, "decision making criteria" is used as a collective term for values, goals, performance objectives and performance factors which will be clarified in the following.
3. The construction of value functions of input and output factors to operationalize objectives corresponds with the underlying idea of a generalized DEA approach proposed by Dyckhoff and Allen (2001).

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**Table 1:** The performance criteria of German savings banks from a goal-oriented perspective

| **Intermediation approach** | | | **Production approach** | | |
|---|---|---|---|---|---|
| Objectives | Direction | Measured by | Objectives | Direction | Measured by |
| Vast network of branches // Accessibility of banking services for customers | Max.! | Number of employees | Vast network of branches // Accessibility of banking services for customers | Max.! | Number of employees |
| Intermediation of funds // Financial compensation for employees | Max.! | Loan volume (€) + customer deposit volume (€) | Provision of interest banking services // Financial compensation for employees | Max.! | Loan volume (€) + customer deposit volume (€) |
| Financial and non-financial resources | Min.! | Interest expenses (€) + non-interest expenses (€) | Provision of non-interest banking services | Max.! | Non-interest income (€) |
| Credit risks | Min.! | Loan loss provision (€) | Operating resources | Min.! | Non-interest expenses (€) |

*3.1. Specifying the fundamental values of key stakeholders*

The aim of the first step is to specify a reference value system for judging organizational performance. This corresponds with a value-focused thinking approach for decision making (Keeney 1992, especially Part 1 and 2). Following Merchant (1982), among others, our framework adopts the view that the ultimate purpose of any organization is to generate desirable values for key stakeholders, which can be labeled as stakeholder value rationality.

On this basis, the overall reference values for judging the performance of the German savings banks are specified through the perspectives of four groups of stakeholders. The primary stakeholder of a German savings bank is its local *municipality* who represents the bank in the absence of a private owner. In this role, the municipality is concerned with not only the *accessibility of banking services for the local customer community* but also the *commercial sustainability of the local savings bank* (DSGV 2012a).

In addition to owners, the customers, employees and regulators are also broadly considered as prominent stakeholders (see, e.g., Neely et al. 2001). In the case of the German savings banks, these stakeholders even participate in the banks' supervisory boards. They are thus considered as secondary stakeholders in our framework. With a view to their core values, the *customers* are concerned with the *costs and quality of banking services*, the *employees* attach importance to the *compensation* for their work efforts (consisting of financial as well as non-financial components) and the *regulators* strive to guarantee the *sustainability of the banking system*.

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Table 2 summarizes the value reference system of a German savings bank, constituted through the main concerns of its key stakeholders.

**Table 2:** Value reference system of a German savings bank

| **Key stakeholders** | **Fundamental values** |
|---|---|
| Municipality | • Accessibility of banking services for the local customer community<br>• Commercial sustainability of the local savings bank |
| Customers | • Costs and quality of banking services |
| Employees | • Compensation |
| Regulators | • Sustainability of the banking system |

*3.2. Identifying the overall goals*

The second step of the DPM framework addresses the rationality of organizations in translating the stakeholder expectations into their overall goals, given cognitive and motivational constraints. In the absence of global rationality due to complexity and uncertainty, organizations usually take heuristic methods to search for the satisfactory alternatives which may respond to only a part of all stakeholder expectations (Simon 1972). Our framework illustrates the overall goals of organizations through the behavior models and strategies. While the *behavior model* characterizes the operating process and the implicit goals of that process, the *strategy* captures the goals pursued in response to contextual factors.

For the case of the German savings banks, only the operating process in bank behavior models will be further taken into account since the profit maximization assumption of these conventional models is not applicable for savings banks. Hence, for the intermediation approach, our framework takes the *fund intermediating process* into account, following Sealey and Lindley (1977). Under the intermediation approach, banks are defined as financial intermediaries of which the key function is "the borrowing of funds from surplus spending units and lending those funds to deficit spending units" (Sealey and Lindley 1977, p. 1252). Regarding the production approach, the *service producing process* is emphasized, following Benston (1965) who characterized banks as service providers and treated the transactions and documents processed by bank staff as the key outputs.

Concerning the strategy aspect, the German savings banks are coordinated by the DSGV. This umbrella organization proclaims that the banks together strive for "*maintaining a vast network of branches* [emphasis added], to ensure personal contact and advice – even in less prosperous economic regions – for all types of customers" (DSGV 2011). As for the business scope, the banks are committed to *focusing on borrowing-lending business* as the core

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business, “financ[ing] themselves predominantly through customer deposits, and through the proceeds generated by their customer business” (DSGV 2011).

Table 3 lists the overall goals of German savings banks identified via their behavior model and strategy.

**Table 3:** Overall goals of German savings banks

| **Source** | **Goals** |
|---|---|
| Behavior model | • Intermediation approach: Fund intermediating process *versus*<br>• Production approach: Service producing process |
| Strategy | • Maintaining a vast network of branches<br>• Focusing on borrowing-lending business |

*3.3. Specifying performance objectives*

The third step relates to specific performance objectives which serve to quantify how the behaviors and strategies of organizations correspond with their stakeholder values. A helpful linkage between the stakeholder approach and the objective-based performance evaluation can be provided by the purpose rationality concept of Weber (1978, p. 26). On this basis, the following categories of objectives can be defined:

- the *primary objectives* reflect the original purposes of an action which aim at the expectations of the primary stakeholders;
- the *resources* are the means employed in the production process to achieve the primary objectives;
- the *positive side effects* as well as the *negative side effects* refer to the further impacts of the production process on the expectations of both the primary and secondary stakeholders.

With respect to efficiency measurement, the primary objectives and the positive side effects are to be maximized, while the resources and the negative side effects are to be minimized.

In the intermediation model for a German savings bank, the *intermediation of funds* and the provision of a *vast network of branches* can be identified as its primary objectives to meet the respective expectations of the municipality. The necessary resources for the fund intermediating process include both financial and non-financial resources. Concerning positive side effects, the specific operating process and strategy of the savings banks can also ensure the accessibility of *banking services for customers* as well as the *financial compensation for employees* through profit from the fund to be intermediated. As a negative

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side effect, *credit risks* incurring from the process are taken into account which are relevant for all stakeholder groups.

In the case of the production approach, the role of the German savings banks as providers of both interest and non-interest banking services is addressed. Concerning the expectations of the municipality, the primary objectives should thus comprise the *provision of interest and non-interest banking services* as well as the *vast network of branches*. The resources for the service producing process include the *operating resources* only, since exclusively financial resources are considered as inputs for the fund intermediating process. Also, as the primary focus is given to the processing of documents and transactions rather than to the intermediating of funds, the production approach does not include credit risks as a negative side effect. The positive side effects are identical to the intermediation approach, i.e. they comprise the *accessibility of banking services for customers* and the *financial compensation for employees*.

*3.4. Deriving performance factors*

The last step of the DPM framework focuses on the factor setting level which concretizes the performance objectives through value functions of input/output factors. These factors serve as objective attributes in the sense of the prescriptive decision theory (see, e.g., Eisenführ et al. 2010, p. 72–77). It is important to note that not only the quantity of input and output factors is relevant; the minimizing or maximizing preference direction imposed on the factors in relation to performance objectives (regardless whether the factors are inputs or outputs) must also be taken into account.

With respect to the intermediation approach, Tobin (1963) pointed out that the essential function of a financial intermediary is to satisfy simultaneously the portfolio preferences of borrowers and lenders. Both deposits and loans are desirable, indicating the success of the process. Therefore, the objective "intermediation of funds" is here measured by *the sum of loan volume and customer deposit volume,* weighted naturally by their dollar value. This function can also be used to measure the "financial compensation for employees", since this objective is determined by the profitability of banks generated from the fund intermediating process. Concerning the two other objectives to be maximized, the "vast network of branches" and the "accessibility of banking services for customers", our study chooses the *number of employees* as a proxy for both of them. The objective "financial and non-financial resources" that banks aim at minimizing in the fund intermediating process can be covered by

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*interest expenses and non-interest expenses*.[4] As the second objective to be minimized, "credit risks" can be measured by the proxy *loan loss provision* as the funds set aside by banks to cover the anticipated loan losses (see, e.g., Pasiouras 2008).

With regard to the production approach, the objective "provision of interest and non-interest banking services" is concretized by two functions: The non-interest services can be measured by the *non-interest income*, the interest services the *sum of loan volume and customer deposit volume*, weighted naturally by their dollar value. The latter function is also suitable to cover the objective "financial compensation for employees". For measuring the two further objectives to be maximized, the "vast network of branches" and the "accessibility of banking services for customers", the *number of employees* is proposed, like in the intermediation approach. Finally, the "operating resources" are considered as the objective to be minimized. This objective can be measured via the operating expenses which are equivalent to the *non-interest expenses* of banks.

## 4. Empirical analysis

### *4.1. DEA model for the German savings banks*

To enable the goal-oriented efficiency measurement, the generalized DEA approach (GDEA) is applied. This approach has been introduced by Dyckhoff and Allen (2001) in the context of ecological efficiency. The distinction between GDEA and traditional DEA stems from the production model they address. Originally, DEA captures a purely technical production model that focuses on inputs and outputs of a transformation process as performance criteria. In contrast, GDEA is based on a decision-oriented production model (Dyckhoff 2003) which takes performance objectives into account when modeling the production process. As a result, GDEA models are differentiated from traditional DEA models by the assumption that the

4. Non-interest expenses = personnel expenses + other operating expenses. It is acknowledged here that a possible contradiction in the models may arise since the number of employees has been above selected as the proxy to illustrate objectives for maximizing. We tried to diminish the resulted shortcoming by not directly taking personnel expenses for minimizing. It can be interpreted that to be more efficient, banks are suggested to focus more on saving other operating expenses and interest expenses. With objectives to widen the branch networks and ensure banking service accessibility, it is more challenging and less desirable to cut the personnel expenses itself. If data is available, it is recommended that the number of branches can be a better proxy.

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efficiency of a decision making unit (DMU) results in the first place from the pursued objectives. Inputs and outputs only play an indirect role as they serve to quantify these objectives by appropriate value functions. The corresponding GDEA models for the German savings banks as DMUs take the objectives for minimizing and objectives for maximizing derived in Section 3.3 as its variables.

The regional principle and public mandate restrict German savings banks in expanding or reducing the scales on their own interest. As a result, the banks may operate with increasing or decreasing returns to scale technology. Like previous efficiency studies of savings banks (e.g., Williams 2008; García-Cestona and Surroca 2008), we therefore assume a variable returns to scale (VRS) technology for the German savings banks. Furthermore, the orientation is given toward the objectives for maximizing with an aim to draw attention to how the savings banks achieve their primary objectives and create positive side effects. Consequently, the proposed GDEA model corresponds to the traditional BCC-O model (see Banker et al. 1984). Within this GDEA model, a specific $\mathrm{DMU}_\rho$ $(\rho = 1, \dots, \pi)$ is characterized by $s$ objectives for minimizing $k_{i\rho}$with $i = 1, \dots, s$ and $r$ objectives for maximizing $l_{j\rho}$ with $j = 1, \dots, r$, and each of the objectives is constructed as a value function of input and output factors.[5] The efficiency score $\theta_o$ for a specific $\mathrm{DMU}_o$ thus can be determined by solving the following problem:

$$\begin{aligned} \max \quad & \theta_o && (1)\\ \text{s.t.} \quad & \textstyle\sum_{\rho=1}^{\pi} \lambda_\rho l_{j\rho} - \theta_o l_{jo} \geq 0 && j = 1, \dots, r \\ & \textstyle\sum_{\rho=1}^{\pi} \lambda_\rho k_{i\rho} - k_{io} \leq 0 && i = 1, \dots, s \\ & \textstyle\sum_{\rho=1}^{\pi} \lambda_\rho = 1 \\ & \lambda_\rho \geq 0 \ \ \forall \rho \end{aligned}$$

Considering the specific data set of which the descriptive statistics are provided in the Appendix, the VRS assumption and orientation toward objectives for maximizing are important for the intermediation model. This model requires transforming the loan loss provision variable due to negative values which occurred in every year of the studied period. Particularly after the financial crisis, a large number of the German savings banks recorded negative loan loss provisions. In order to ensure that all data for DEA are positive, it is necessary to add a sufficiently large number to the values of the loan loss provision variable.

5. More details on the construction of value functions of input and output factors have been illustrated in Dyckhoff and Ahn (2010).

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Ali and Seiford (1990) have proved that the assumptions corresponding with the BCC-O model guarantees the invariance of the results in reference to the described data transformation.

In addition to the intermediation efficiency and production efficiency which are specified based upon the distinct goal set of the German savings banks, our empirical analysis also considers the conventional profit efficiency model which is specified based upon the profit maximization assumption. The profit efficiency model classifies the sources of income and expenses of a bank into the interest and non-interest category. As a result, interest income and non-interest income are taken as objectives for maximizing while interest expenses and non-interest expenses are taken as objectives for minimizing in the respective DEA model.

Table 4 gives an overview of the derived DEA variables. For all three models, an equal number of variables is considered. The comparison across the models can thereby avoid the pitfall caused by the sensitivity of DEA-based efficiency scores to the number of variables.[6]

**Table 4:** Overview of the DEA variables

| Model | Variable | Value functions for variables |
|---|---|---|
| **Intermediation efficiency model (I)** | $l_1^I$ | oan volume (€) + customer deposit volume (€) |
| | $l_2^I$ | umber of employees |
| | $k_1^I$ | nterest expenses (€) + non-interest expenses (€) |
| | $k_2^I$ | oan loss provision (€) |
| **Production efficiency model (P)** | $l_1^P$ | oan volume (€) + customer deposit volume (€) |
| | $l_2^P$ | on-interest income (€) |
| | $l_3^P$ | umber of employees |
| | $k_1^P$ | non-interest expenses (€) |
| **Profit efficiency model (FT)** | $l_1^{FT}$ | interest income (€) |
| | $l_2^{FT}$ | non-interest income (€) |
| | $k_1^{FT}$ | interest expenses (€) |
| | $k_2^{FT}$ | non-interest expenses (€) |

Taking Sparkasse Hannover in the year 2006 as an example, Table 5 illustrates the variables and data for running the respective production efficiency model.

6. DEA results are sensitive in the way that when the number of performance criteria increase, ceteris paribus the proportion of DMUs rated as efficient as well as the average efficiency score of all DMUs increase accordingly. See Epstein and Henderson (1989) for an discussion on this issue.

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**Table 5:** Variables and data for the production efficiency model of Sparkasse Hannover in 2006

| **Objectives as DEA variables** | $l^P_{1\ Hannover06}$ | $l^P_{2\ Hannover06}$ | $l^P_{3\ Hannover06}$ | $k^P_{1\ Hannover06}$ |
|---|---|---|---|---|
| **Input/output factors for quantifying the objectives** | Loans (mil EUR) | Customer deposits (mil EUR) | Non-interest income (mil EUR) | Number of employees | Non-interest expenses (mil EUR) |
| | 8853 + 7844 | 110 | 2670 | 263 |

The GDEA efficiency score of this bank in the respective model is generated from the following linear problem:

$$\max \quad \theta^P_{Hannover06} \tag{2}$$

$$\text{s.t.} \quad \sum_{\rho=1}^{396} \lambda_\rho l^P_{1\rho} - (8853+7844)\theta^P_{Hannover06} \geq 0$$

$$\sum_{\rho=1}^{396} \lambda_\rho l^P_{2\rho} - 110\theta^P_{Hannover06} \geq 0$$

$$\sum_{\rho=1}^{396} \lambda_\rho l^P_{3\rho} - 2670\theta^P_{Hannover06} \geq 0$$

$$\sum_{\rho=1}^{396} \lambda_\rho k^P_{1\rho} - 263 \leq 0$$

$$\sum_{\rho=1}^{396} \lambda_\rho = 1$$

$$\lambda_\rho \geq 0 \quad \forall \rho$$

*4.2. Result discussion*

This section analyzes the DEA efficiency of the 396 German savings banks on the basis of the performance measurement framework derived above. The section starts with a discussion on the efficiency across the intermediation, production and profit efficiency model to uncover how the banks meet the values of their stakeholders, especially in comparison with the profit maximizing goal. Then, the change in efficiency of the German savings banks during the period 2006–2011 is examined to explore how well they overcame the 2008/09 financial crisis. Finally, scale efficiency results are analyzed.

*4.2.1. Efficiency under different behavior models*

Table 6 illustrates the DEA results for the three models and the results of comparative tests between them, applying the Wilcoxon signed rank test. As the non-parametric alternative to the paired t-test, the Wilcoxon signed rank test can provide statistical inferences while requiring no strict assumptions on the distribution of data like parametric approaches (Sueyoshi and Aoki 2001). For our data set, a preliminary analysis revealed that the assumption on the normal distribution of the differences in efficiency results between two

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models (as required for the t-test) is not valid. It is rather found that the distribution of the differences is roughly symmetric. Therefore, the assumption required for the Wilcoxon test can be considered to be satisfied (see, e.g., Randles 1988). Based upon the rankings of the paired differences between the efficiency results under the paired models rather than the raw data, the Wilcoxon test examines whether the median difference is equal to zero. Our study carried out the test with the significance level $\alpha = 0.05$, i.e. the null hypothesis that the efficiency results under the paired models are identical is rejected if p-value $\leq 0.05$.

**Table 6:** Efficiency of the German savings bank sector in different behavior models[7]

| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
|---|---|---|---|---|---|---|
| Intermediation efficiency | 85.27 | 86.35 | 86.01 | 82.03 | 79.07 | 80.34 |
| Production efficiency (%) | 85.34 | 84.25 | 82.80 | 82.41 | 82.99 | 84.78 |
| Profit efficiency (%) | 79.06 | 76.82 | 75.49 | 79.20 | 78.71 | 81.46 |
| **Production efficiency vs. intermediation efficiency** | $\mathbf{P_{06}^{06} - I_{06}^{06}}$ | $\mathbf{P_{07}^{07} - I_{07}^{07}}$ | $\mathbf{P_{08}^{08} - I_{08}^{08}}$ | $\mathbf{P_{09}^{09} - I_{09}^{09}}$ | $\mathbf{P_{10}^{10} - I_{10}^{10}}$ | $\mathbf{P_{11}^{11} - I_{11}^{11}}$ |
| z-value | –.446[b] | –4.792[b] | –8.609[b] | –.505[c] | –8.089[c] | –8.820[c] |
| p-value | .655 | .000 | .000 | .614 | .000 | .000 |
| **Production efficiency vs. profit efficiency** | $\mathbf{P_{06}^{06} - FT_{06}^{06}}$ | $\mathbf{P_{07}^{07} - FT_{07}^{07}}$ | $\mathbf{P_{08}^{08} - FT_{08}^{08}}$ | $\mathbf{P_{09}^{09} - FT_{09}^{09}}$ | $\mathbf{P_{10}^{10} - FT_{10}^{10}}$ | $\mathbf{P_{11}^{11} - FT_{11}^{11}}$ |
| z-value | –2.345[c] | –2.312[c] | –1.111[c] | –6.953[c] | –9.916[c] | –7.916[c] |
| p-value | .000 | .000 | .000 | .000 | .000 | .000 |
| **Intermediation efficiency vs. profit efficiency** | $\mathbf{I_{06}^{06} - FT_{06}^{06}}$ | $\mathbf{I_{07}^{07} - FT_{07}^{07}}$ | $\mathbf{I_{08}^{08} - FT_{08}^{08}}$ | $\mathbf{I_{09}^{09} - FT_{09}^{09}}$ | $\mathbf{I_{10}^{10} - FT_{10}^{10}}$ | $\mathbf{I_{11}^{11} - FT_{11}^{11}}$ |
| z-value | –0.480[c] | –3.686[c] | –4.251[c] | –6.562[c] | –1.821[c] | –1.610[b] |
| p-value | .000 | .000 | .000 | .000 | .069 | .107 |

[b] z-value results are calculated based on negative ranks
[c] z-value results are calculated based on positive ranks

7. In reference to equation (1), the average efficiency is calculated based on $1/\theta_o$.
I: Intermediation efficiency; P: Production efficiency; FT: Profit efficiency.
The superscript refers to the year of observation; the subscript refers to the period for constructing the benchmarking frontier.

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It is obvious that the average efficiency results in all three models are not near 100%. Such evidence shows a considerable possibility for the German savings bank sector to improve the efficiency to better fulfill the expectations of their key stakeholders. Comparing the intermediation and the production efficiency scores, a significant difference in four out of six years is revealed, i.e. except for the years 2006 and 2009. Specifically, the production efficiency results significantly outperformed the intermediation efficiency results in 2010 and 2011 and vice versa in 2007 and 2008. It thus confirms that the two models indeed capture different perspectives on the German savings banks' performance.

Throughout the period, the profit efficiency scores have never been significantly higher than the production and intermediation efficiency scores. In fact, the profit efficiency scores are significantly lower than the production efficiency scores for the whole period and significantly lower than the intermediation efficiency scores from 2006 to 2009. The results suggest that the savings banks put more emphasis on fulfilling their public mandate to meet the expectations of multiple stakeholders than on maximizing profit. To a certain extent, the fact that the profit efficiency model does not evaluate the savings banks against the whole goal set they aim at can explain its low efficiency results.

*4.2.2. Efficiency change throughout the period*

To examine the change in the efficiency of German savings bank sector throughout the period, we apply a window analysis (see Charnes et al. 1985). For each model, we choose a window width of two time periods by constructing adjacent period benchmarking frontiers from 2006–2011. Hence, each bank in a year is benchmarked against all other observations in both years.

The Wilcoxon test with the assumption specified in Section 4.2.1 is again employed to compare the DEA results in different years given the symmetric distribution of the differences. Table 7 summarizes the average efficiency of the German savings bank sector regarding adjacent period frontiers and respective Wilcoxon test results.

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**Table 7:** Average efficiency of the German savings banks in reference to adjacent period frontiers and comparative Wilcoxon test results

| **Intermediation efficiency** | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| $\mathbf{I}_{06/07}^{06}$ | $\mathbf{I}_{06/07}^{07}$ | $\mathbf{I}_{07/08}^{07}$ | $\mathbf{I}_{07/08}^{08}$ | $\mathbf{I}_{08/09}^{08}$ | $\mathbf{I}_{08/09}^{09}$ | $\mathbf{I}_{09/10}^{09}$ | $\mathbf{I}_{09/10}^{10}$ | $\mathbf{I}_{10/11}^{10}$ | $\mathbf{I}_{10/11}^{11}$ |
| 85.23 | 80.99 | 85.77 | 83.36 | 73.11 | 81.89 | 70.54 | 79.07 | 76.77 | 79.91 |
| $\mathbf{I}_{06/07}^{07} - \mathbf{I}_{06/07}^{06}$ | | $\mathbf{I}_{07/08}^{08} - \mathbf{I}_{07/08}^{07}$ | | $\mathbf{I}_{08/09}^{09} - \mathbf{I}_{08/09}^{08}$ | | $\mathbf{I}_{09/10}^{10} - \mathbf{I}_{09/10}^{09}$ | | $\mathbf{I}_{10/11}^{11} - \mathbf{I}_{10/11}^{10}$ | |
| z = –14.818[b] | | z = –8.942[b] | | z = –16.832[c] | | z = –17.001[c] | | z = –11.685[c] | |
| p = 0.000 | | p = 0.000 | | p = 0.000 | | p = 0.000 | | p = 0.000 | |
| **Production efficiency** | | | | | | | | | |
| $\mathbf{P}_{06/07}^{06}$ | $\mathbf{P}_{06/07}^{07}$ | $\mathbf{P}_{07/08}^{07}$ | $\mathbf{P}_{07/08}^{08}$ | $\mathbf{P}_{08/09}^{08}$ | $\mathbf{P}_{08/09}^{09}$ | $\mathbf{P}_{09/10}^{09}$ | $\mathbf{P}_{09/10}^{10}$ | $\mathbf{P}_{10/11}^{10}$ | $\mathbf{P}_{10/11}^{11}$ |
| 83.62 | 82.76 | 80.16 | 82.51 | 82.25 | 80.25 | 79.92 | 82.15 | 82.41 | 82.50 |
| $\mathbf{P}_{06/07}^{07} - \mathbf{P}_{06/07}^{06}$ | | $\mathbf{P}_{07/08}^{08} - \mathbf{P}_{07/08}^{08}$ | | $\mathbf{P}_{08/09}^{09} - \mathbf{P}_{08/09}^{08}$ | | $\mathbf{P}_{09/10}^{10} - \mathbf{P}_{09/10}^{09}$ | | $\mathbf{P}_{10/11}^{11} - \mathbf{P}_{10/11}^{10}$ | |
| z = –2.255[b] | | z = –5.118[c] | | z = –5.865[b] | | z = –6.781[c] | | z = –.470[b] | |
| p = 0.024 | | p = 0.000 | | p = 0.000 | | p = 0.000 | | p = 0.638 | |

[b] z-value results are calculated based on negative ranks
[c] z-value results are calculated based on positive ranks

Concerning the intermediation efficiency of the German savings banks, a significant declining trend can be seen from 2006–2008, followed by a significant improving trend till the end of the studied period. These results allow some interesting interpretations. It can be inferred that the impacts of the financial crisis on the intermediation efficiency of the German savings banks were most serious in 2008. Afterwards, the sector has managed to quickly recover from the crisis right in 2009 and continued to grow in 2010. Examining the context, it is the continuous rise in short-term interest rates from 2006 to 2008 that caused the rise in the total expenses which is a variable included in the intermediation model and consequently led to the decline in the respective efficiency of the sector. Noteworthy, the financial crisis also brought about considerable inflows of funds from private customers to the savings banks since they were perceived by the public to be safer than other types of banks (BaFin 2009). The solid deposit base has facilitated the savings banks to continuously finance the enterprises and self-employed sector even in critical periods. On average, the intermediation of funds of the savings banks throughout the period kept constantly increasing despite the financial crisis. In addition to the fulfillment of the public mandate, such process can generate earnings for the

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savings banks from maturity transformation. With a dominant proportion of loans granted to small- and medium-sized enterprises being long-term, the savings banks have profited from the substantial interest spread between short- and long-term capitals (Deutsche Bundesbank 2009), gaining their intermediation efficiency back from the year 2009 onward.

Regarding the production efficiency, the fluctuation in the performance of German savings bank sector is obvious. A significant regression is seen in the two adjacent periods 2006/07 and 2008/09, while a significant progression is seen in 2007/08 and 2009/10. In comparison with the adjacent years (both before and after), the two years 2007 and 2009 displayed the poorer performance. Taking the efficiency results against annual frontiers into account, it can be indicated that the most serious impact of the financial crisis on their production efficiency occurred in 2009 while the recovery can be witnessed from the year 2010. Examining the variations in the variable set of the production model, it is shown that the decline in the non-interest income and the rise in the non-interest expenses were the main causes for the poor performance in 2009. In more detail, the decline in non-interest income was primarily attributed to the reduction in the net commissions received due to the subdued stock market activity resulted from the financial crisis (Deutsche Bundesbank 2009). At the same time, the rise in the non-interest expenses is caused by the significant increase in administrative spending. In 2009, the German banking system recorded the highest administrative spending ever of 82.2 billion euro, showing an increase by 4.4% in comparison with the year 2008 due to the 7.0% rise in staff costs (Deutsche Bundesbank 2009).

To summarize the impacts of the 2008/09 financial crisis on the savings banks performance, DEA results infer that the intermediation efficiency was most seriously influenced in 2008, while the production efficiency recorded the poorest result in 2009. Afterward, the sector has shown a quick recovery regarding both fund intermediating and service producing process. This is in line with the statement of the German Savings Bank Finance Group that the business model of their savings banks "has […] passed with flying colours" through the 2008/09 financial crisis (DSGV 2011).

*4.2.3. Scale efficiency*

This section analyzes the impact of scale size on the efficiency of the German savings banks. Scale efficiency is determined as the ratio of the DEA efficiency score with CRS (constant returns to scale) assumption and with VRS assumption. The lower the scale efficiency is, the higher is "the impact of scale size on the productivity of a DMU" (Thanassoulis 2001, p. 140). Here, the analysis is only conducted for the production efficiency model. The reason is that the intermediation efficiency model with transformed values of the loan loss provision

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variable does not ensure the invariance of the results under the CRS assumption. Table 8 illustrates the scale efficiency of the German savings bank sector with the sample of 396 banks being grouped into three clusters using the number of employees as proxy for bank size. The three thresholds to classify the clusters were chosen to mark the change in the magnitude and the direction of the correlation between scale efficiency scores and bank size.

**Table 8:** Scale efficiency of the German savings banks

| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
|---|---|---|---|---|---|---|
| **Whole sample** | | | | | | |
| No. of scale efficient banks | 36 | 26 | 24 | 15 | 16 | 17 |
| No. of banks with DRS technology | 253 | 267 | 205 | 262 | 242 | 300 |
| Average scale efficiency (%) | 96.81 | 96.28 | 95.71 | 95.06 | 95.95 | 95.74 |
| Standard deviation (%) | 3.74 | 4.56 | 4.95 | 5.21 | 4.29 | 4.50 |
| **Large-sized bank group (with > 500 employees)** | | | | | | |
| No. of observations | 142 | 145 | 148 | 150 | 145 | 146 |
| % of scale efficient banks | 0 | 2.17 | 1.35 | 1.33 | 1.38 | 0.7 |
| % of banks with DRS technology | 100 | 97.93 | 98.65 | 98.67 | 98.62 | 99.3 |
| Average scale efficiency (%) | 94.22 | 93.66 | 92.06 | 91.51 | 93.09 | 92.71 |
| Standard deviation (%) | 3.69 | 5.80 | 5.52 | 5.48 | 4.39 | 5.02 |
| Correlation | –.679** | –.812** | –.777** | –.757** | –.659** | –.783** |
| **Medium-sized bank group (with 150 – 500 employees)** | | | | | | |
| No. of observations | 193 | 188 | 183 | 182 | 187 | 185 |
| % of scale efficient banks | 16.58 | 11.17 | 11.48 | 6.59 | 6.95 | 7.57 |
| % of banks with DRS technology | 55.96 | 64.89 | 32.24 | 62.09 | 52.94 | 81.08 |
| Average scale efficiency (%) | 99.15 | 98.47 | 98.91 | 98.33 | 98.87 | 98.19 |
| Standard deviation (%) | 1.21 | 1.75 | 1.51 | 2.69 | 1.18 | 1.70 |
| Correlation | –.386** | –.411** | –.202** | –.344** | –.451** | –.521** |
| **Small-sized bank group (with < 150 employees)** | | | | | | |
| No. of observations | 61 | 63 | 65 | 64 | 64 | 65 |
| % of scale efficient banks | 6.56 | 3.17 | 1.54 | 1.56 | 1.56 | 3.07 |
| % of banks with IRS technology | 88.52 | 92.06 | 98.46 | 96.88 | 98.44 | 89.23 |
| Average scale efficiency (%) | 95.40 | 95.77 | 94.98 | 94.09 | 93.91 | 95.56 |
| Standard deviation (%) | 4.47 | 3.74 | 3.75 | 4.06 | 4.31 | 4.65 |
| Correlation | .853** | .796** | .833** | .809** | .794** | .844** |

** significant at the 0.01 level (2-tailed)

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The results indicate a modest divergence from the CRS technology of the German savings banks sector. However, the number of banks operating with an absolute CRS technology is not very high. There are only about 5.6% of the banks which were scale efficient, on average. Most of the other banks were operating with decreasing returns to scale (DRS). Throughout the period, more than 64% of the German savings banks have been experiencing a DRS technology. Notably, in the cluster of large-sized banks, all of the banks except for the scale efficient banks were operating with a DRS technology over the period. Most of the banks with an increasing returns to scale (IRS) technology were the small-sized ones. Within the cluster of small-sized banks, there were about 94% of banks operating with IRS, on average.

Comparing the three clusters throughout the period, the large-sized bank group had the lowest average efficiency scores, while the medium-sized bank group consistently maintained the top position, followed by the small-sized bank group. This result points to a potential for large-sized banks in the first place to improve their efficiency by changing their operating scale. However, future research on such issues will be necessary, especially with regard to the fact that the banks are restricted by the regional principle and public mandate.

The medium-sized bank group also showed the smallest dispersion in scale efficiency. In contrast, except for the year 2006, the large-sized bank had the strongest dispersion in the distribution of their scale efficiency results. While both the large-sized group and the medium-sized group held a negative correlation between the scale efficiency and the number of employees, the small-sized banks maintained a positive one throughout the period. These results indicate that large-sized banks and medium-sized banks tended to have a lower scale efficiency when the number of employees was higher. At the same time, the small-sized banks showed an opposite situation, i.e. the scale efficiency was higher when the number of employees was bigger. Also, among the three groups, the small-sized group and the large-sized group showed a relatively strong correlation between bank size and scale efficiency while such correlation was relatively weak for the medium-sized group over the period. In summary, the three clusters are distinguished regarding both the magnitude and the direction of the correlation between bank size and scale efficiency over the period from 2006 to 2010.

In order to identify the optimum scale size regarding the scale efficiency of the German savings banks, they are further classified into smaller groups. Table 9 describes the classification, and Fig. 1 illustrates the box plot of each group for the years 2006–2011.

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**Table 9:** Classification of the German savings banks

| **Group** | **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** |
|---|---|---|---|---|---|---|---|---|---|---|---|
| No. of employees | whole sample | < 100 | 100 – 150 | 150 – 200 | 200 – 250 | 250 – 300 | 300 – 350 | 350 – 400 | 400 – 500 | 500 – 1000 | > 1000 |
| No. of banks (mean) | 396 | 32 | 32 | 26 | 30 | 27 | 30 | 32 | 41 | 99 | 47 |

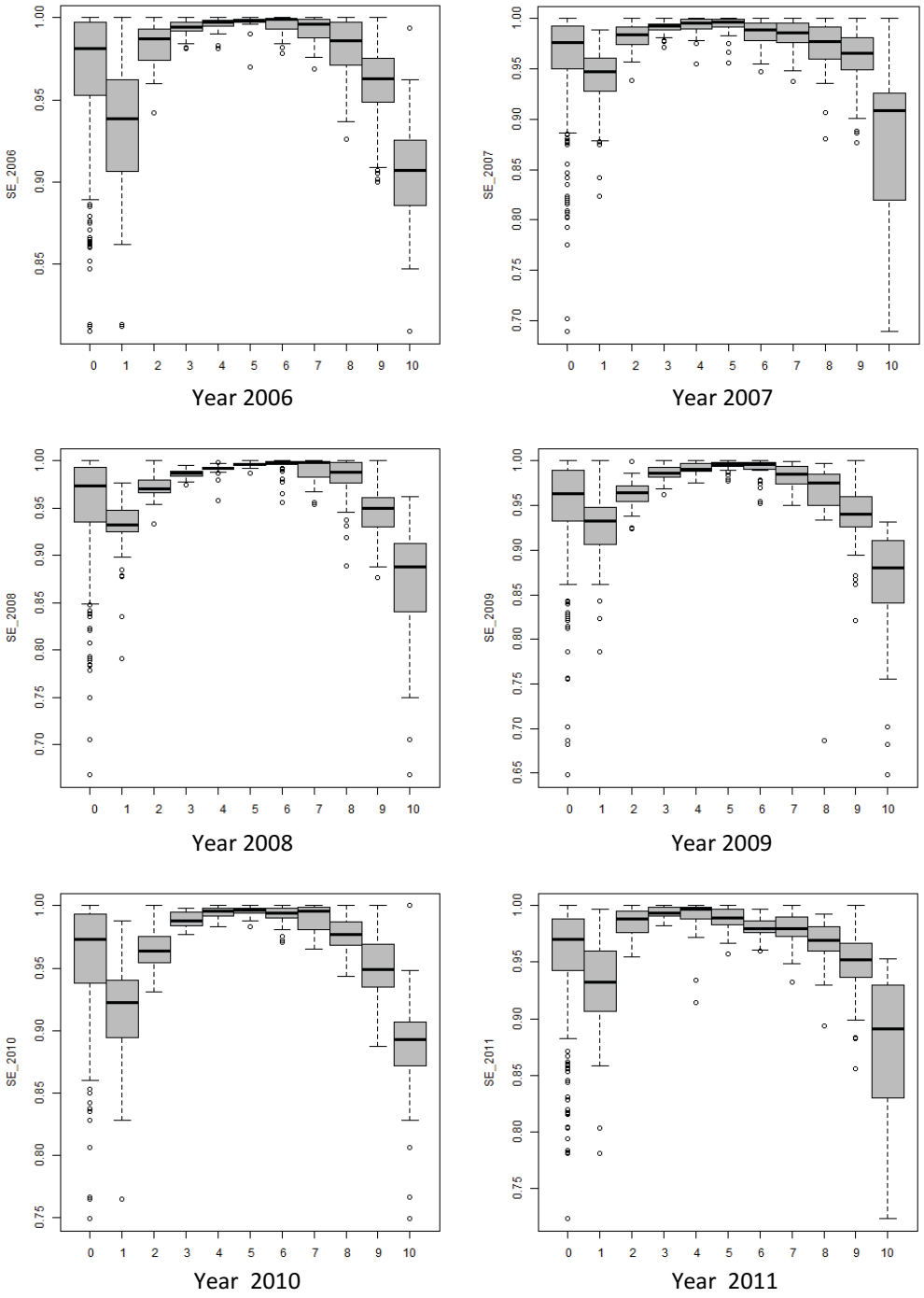


**Fig. 1.** Size versus scale efficiency of the German savings banks

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The box plot illustration indicates that the optimum bank size regarding scale efficiency is within the range of 200 to 300 employees, i.e. the group numbered 4 and 5. These two groups constantly remained in the top three groups which recorded the highest scale efficiency scores with smallest dispersion throughout the period. The median and mean of their scale efficiency scores have never been lower than 98.8% in the period. The results also specify that the banks with more than 1000 employees, i.e. the group numbered 10, have clearly the lowest scale efficiency scores over the examined period.

## 5. Conclusions

Starting from multiple stakeholder values, our study proposes a customized performance measurement framework to capture the distinct goal set of organizations and to systematically derive respective performance criteria applicable for DEA. On this basis, we contribute one of very few DEA studies on the German savings banks and provide evidence on the credit of the savings bank business model from a goal-oriented perspective. The major inferences of the empirical analysis are:

(i) The German savings bank sector shows a considerable potential for efficiency improvement to better fulfill the expectations of its key stakeholders. However, the results clearly vary between the three efficiency models under consideration, highlighting the importance of the model choice in performance measurement. The intermediation model and the production model which consider the distinct goal set of the banks orientated toward multiple stakeholder values in most cases yield significantly higher results than the profit efficiency model which assumes shareholder value orientation. The evidence indicates that the German savings banks spend more effort to meet their stakeholder expectations than to maximize profitability.

(ii) The German savings bank sector has overcome the 2008/09 financial crisis successfully. Although the intermediation model and the production models recorded the poorest performance in 2008 and 2009, respectively, both models reveal a quick recovery of the sector afterwards.

(iii) Regarding scale efficiency, the results show that the cluster of large-sized banks has the lowest average scale efficiency and is operating with DRS. The cluster of medium-sized banks maintains the highest average scale efficiency with the smallest dispersion over the period. The banks with 200 to 300 employees have proved to be the most scale efficient constantly throughout the examined period. This poses a question to the current consolidation trend in the German savings bank sector.

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The empirical results confirm the relevance of the savings bank business model in modern banking systems. The German savings banks do not only contribute significant values to the society even though they may not be of high profitability, but also play an important role in stabilizing the economy in critical periods. Within this context, the evidence also suggests that savings banks should operate with medium size, questioning the persistent merging tendencies in the sector.

Our results are of course necessary to be discussed in detail, especially because the derivation of performance criteria will always remain to some extent subjective. Nevertheless, the DPM framework ensures that performance is linked to stakeholder values, facilitating to derive a rationality-based structure of goals and objectives as well as to quantify these objectives by a comprehensible set of performance factors. The question whether such a factor is desirable or undesirable does not depend on its characterization as input factor or output factor. Rather, its contribution to an objective to be maximized or to be minimized is decisive (see Dyckhoff and Allen 2001).

For future research, we propose to give more attention to the impact of environmental conditions on the DEA results. Being located in different regions of Germany, the respective demographic, economic and politic environment of the savings banks may be of importance (see Tischer 2011). Taking these prevailing circumstances of the banks into account will improve the evaluation of their managers' performance as well as the resulting decisions about proper strategies to increase and secure efficiency.

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**Appendix**

**Table 1A**: Descriptive statistics of the variables in the intermediation efficiency model

| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
|---|---|---|---|---|---|---|
| ***To be maximized:*** | ***sum of loan volume and customer deposit volume (mil. EUR)*** | | | | | |
| Mean | 2845.20 | 2914.16 | 3035.80 | 3107.40 | 3208.52 | 3312.44 |
| Annual change (%) | | 2.42 | 4.17 | 2.36 | 3.25 | 3.24 |
| Standard deviation | 3995.50 | 4067.24 | 4346.22 | 4453.28 | 4583.03 | 4711.16 |
| Min | 152.70 | 156.10 | 151.30 | 153.30 | 152.90 | 154.90 |
| Max | 44473.30 | 44160.80 | 48210.80 | 51097.70 | 53287.70 | 55123.60 |
| ***To be maximized:*** | ***number of employees*** | | | | | |
| Mean | 544.13 | 540.96 | 549.13 | 549.34 | 548.61 | 547.33 |
| Annual change (%) | | –0.58 | 1.51 | 0.04 | –0.13 | –0.23 |
| Standard deviation | 573.04 | 577.57 | 574.97 | 579.37 | 581.55 | 580.22 |
| Min | 39 | 39 | 42 | 39 | 40 | 38 |
| Max | 5189 | 5328 | 5434 | 5547 | 5622 | 5724 |
| ***To be minimized:*** | ***total expenses (mil. EUR)*** | | | | | |
| Mean | 102.16 | 111.73 | 118.46 | 103.57 | 92.80 | 91.71 |
| Annual change (%) | | 9.37 | 6.02 | –12.57 | –10.40 | –1.17 |
| Standard deviation | 147.94 | 166.20 | 175.73 | 145.95 | 128.99 | 132.13 |
| Min | 6.20 | 6.50 | 6.90 | 6.80 | 5.40 | 5.40 |
| Max | 1559.30 | 1798.70 | 1870.30 | 1554.20 | 1442.70 | 1513.00 |
| ***To be minimized:*** | ***loan loss provision (mil. EUR)*** | | | | | |
| Mean | 12.02 | 9.98 | 11.07 | 10.52 | 8.16 | –17.60 |
| Annual change (%) | | –16.97 | 10.92 | –4.97 | –22.43 | –315.69 |
| Standard deviation | 17.69 | 13.94 | 17.43 | 15.75 | 14.54 | 34.32 |
| Min | –6.00 | –94.70 | –34.10 | –6.00 | –37.10 | –363.70 |
| Max | 214.30 | 123.50 | 150.50 | 184.70 | 159.00 | 120.30 |

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**Table 2A**: Descriptive statistics of the variables in the production efficiency model

| **Variables** | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
|---|---|---|---|---|---|---|
| ***To be maximized:*** | ***sum of loan volume and customer deposit volume (mil. EUR)*** | | | | | |
| Mean | 2845.20 | 2914.16 | 3035.80 | 3107.40 | 3208.52 | 3312.44 |
| Annual change (%) | | 2.42 | 4.17 | 2.36 | 3.25 | 3.24 |
| Standard deviation | 3995.50 | 4067.24 | 4346.22 | 4453.28 | 4583.03 | 4711.16 |
| Min | 152.70 | 156.10 | 151.30 | 153.30 | 152.90 | 154.90 |
| Max | 44473.30 | 44160.80 | 48210.80 | 51097.70 | 53287.70 | 55123.60 |
| ***To be maximized:*** | ***non-interest income (mil. EUR)*** | | | | | |
| Mean | 17.44 | 18.63 | 18.25 | 17.87 | 18.07 | 18.16 |
| Annual change (%) | | 6.82 | –2.04 | –2.08 | 1.12 | 0.50 |
| Standard deviation | 26.42 | 27.75 | 27.45 | 26.13 | 25.73 | 25.19 |
| Min | 0.60 | 0.80 | 0.80 | 0.70 | 0.60 | 0.80 |
| Max | 304.60 | 326.90 | 310.30 | 277.50 | 286.80 | 292.40 |
| ***To be maximized:*** | ***number of employees*** | | | | | |
| Mean | 544.13 | 540.96 | 549.13 | 549.34 | 548.61 | 547.33 |
| Annual change (%) | | –0.58 | 1.51 | 0.04 | –0.13 | –0.23 |
| Standard deviation | 573.04 | 577.57 | 574.97 | 579.37 | 581.55 | 580.22 |
| Min | 39 | 39 | 42 | 39 | 40 | 38 |
| Max | 5189 | 5328 | 5434 | 5547 | 5622 | 5724 |
| ***To be minimized:*** | ***non-interest expenses (mil. EUR)*** | | | | | |
| Mean | 46.03 | 47.19 | 46.72 | 47.93 | 46.99 | 47.35 |
| Annual change (%) | | 2.52 | –1.00 | 2.59 | –1.96 | 0.77 |
| Standard deviation | 61.12 | 63.47 | 64.34 | 64.90 | 62.75 | 64.14 |
| Min | 2.80 | 3.00 | 2.90 | 3.10 | 3.20 | 3.10 |
| Max | 650.70 | 660.30 | 689.60 | 694.70 | 747.10 | 779.30 |

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**Table 3A**: Descriptive statistics of the variables in the profit efficiency model

| | **2006** | **2007** | **2008** | **2009** | **2010** | **2011** |
|---|---|---|---|---|---|---|
| ***To be maximized:*** | ***interest income (mil. EUR)*** | | | | | |
| Mean | 51.19 | 48.08 | 48.16 | 52.11 | 54.58 | 55.24 |
| Annual change (%) | | –6.08 | 0.17 | 8.20 | 4.74 | 1.21 |
| Standard deviation | 65.22 | 57.84 | 58.72 | 62.92 | 66.75 | 67.17 |
| Min | 3.50 | 3.00 | 2.90 | 3.80 | 3.80 | 3.50 |
| Max | 732.40 | 558.70 | 591.30 | 710.10 | 768.00 | 768.40 |
| ***To be maximized:*** | ***non-interest income (mil. EUR)*** | | | | | |
| Mean | 17.44 | 18.63 | 18.25 | 17.87 | 18.07 | 18.16 |
| Annual change (%) | | 6.82 | –2.04 | –2.08 | 1.12 | 0.50 |
| Standard deviation | 26.42 | 27.75 | 27.45 | 26.13 | 25.73 | 25.19 |
| Min | 0.60 | 0.80 | 0.80 | 0.70 | 0.60 | 0.80 |
| Max | 304.60 | 326.90 | 310.30 | 277.50 | 286.80 | 292.40 |
| ***To be minimized:*** | ***interest expenses (mil. EUR)*** | | | | | |
| Mean | 56.13 | 64.54 | 71.74 | 55.64 | 45.80 | 44.36 |
| Annual change (%) | | 14.98 | 11.16 | –22.44 | –17.69 | –3.14 |
| Standard deviation | 87.42 | 103.60 | 112.32 | 81.86 | 67.39 | 69.19 |
| Min | 2.90 | 3.20 | 3.60 | 3.00 | 2.00 | 1.90 |
| Max | 908.60 | 1138.40 | 1211.90 | 859.50 | 596.60 | 733.70 |
| ***To be minimized:*** | ***non-interest expenses (mil. EUR)*** | | | | | |
| Mean | 46.03 | 47.19 | 46.72 | 47.93 | 46.99 | 47.35 |
| Annual change (%) | | 2.52 | –1.00 | 2.59 | –1.96 | 0.77 |
| Standard deviation | 61.12 | 63.47 | 64.34 | 64.90 | 62.75 | 64.14 |
| Min | 2.80 | 3.00 | 2.90 | 3.10 | 3.20 | 3.10 |
| Max | 650.70 | 660.30 | 689.60 | 694.70 | 747.10 | 779.30 |

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